

**Seminar: Introduction to ANSI/AGMA/AWEA 6006-A03
Standard for Design and Specification of Gearboxes
for Wind Turbines**

**Sponsored jointly by the
American Gear Manufacturers Association
and the National Renewable Energy Laboratory
National Wind Technology Center
National Renewable Energy Laboratories
Golden, Colorado, USA.**

April 26-27, 2004

Lubrication Contributor:



Herguth Laboratories, Inc.

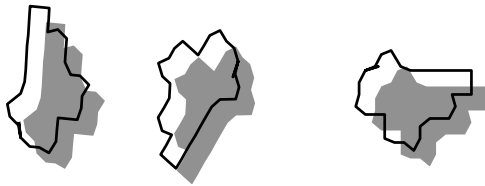


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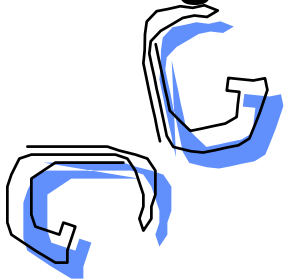
GEARBOX HEALTH
Wear Metals Analysis

MEASURING AND IDENTIFYING WEAR METALS

Fatigue Chunks



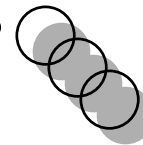
Chips from Cutting Wear



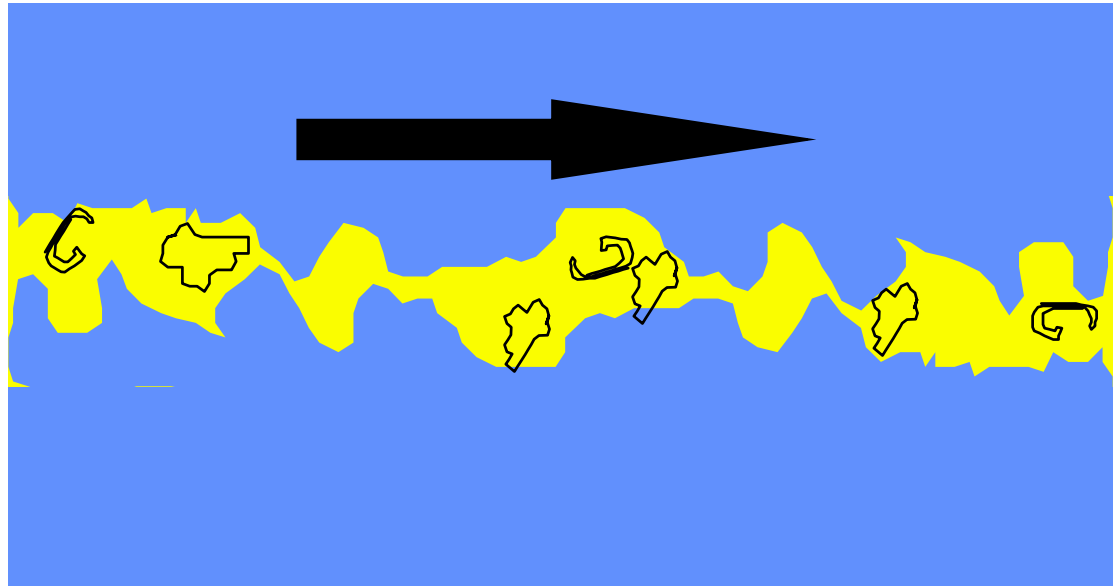
Laminar Wear



Spheres



and
others



Atomic Emission Spectroscopy

- **Metallic Elements**

Emit different colors of light when burned

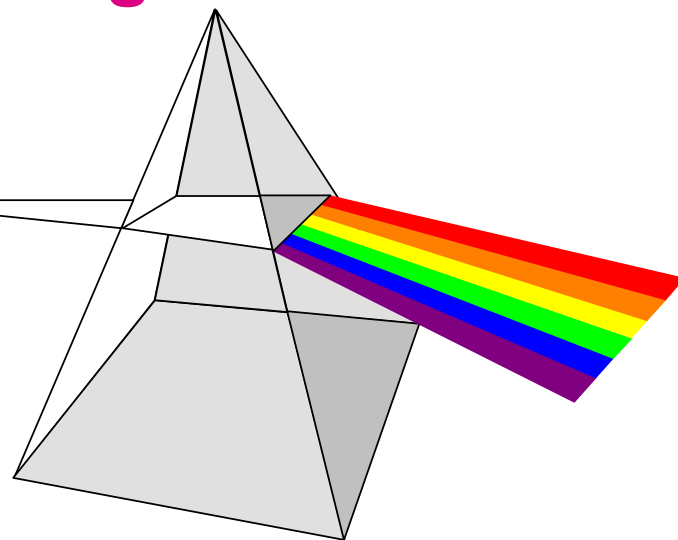
- ✓ **Copper - Green**

- ✓ **Lithium - Deep violet, magenta**

- ✓ **Sodium - Yellow**

- ✓ **Cobalt - Deep Blue**

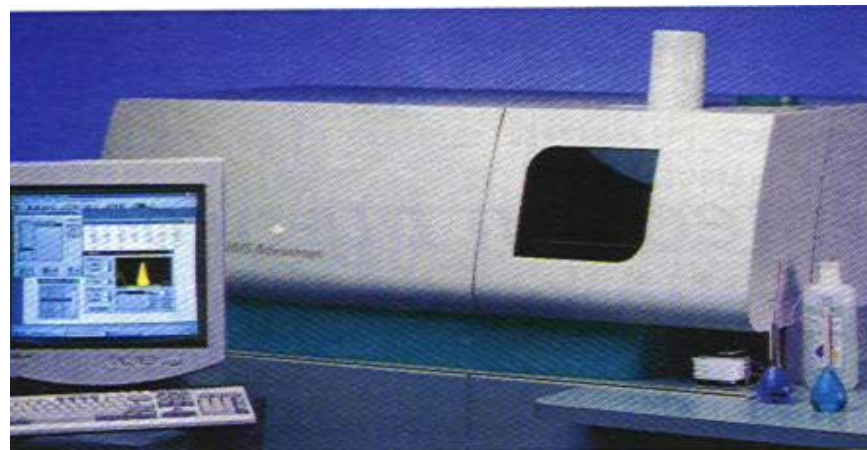
- ✓ **Nickel - Green-Blue**



40 Years of Spectroscopy

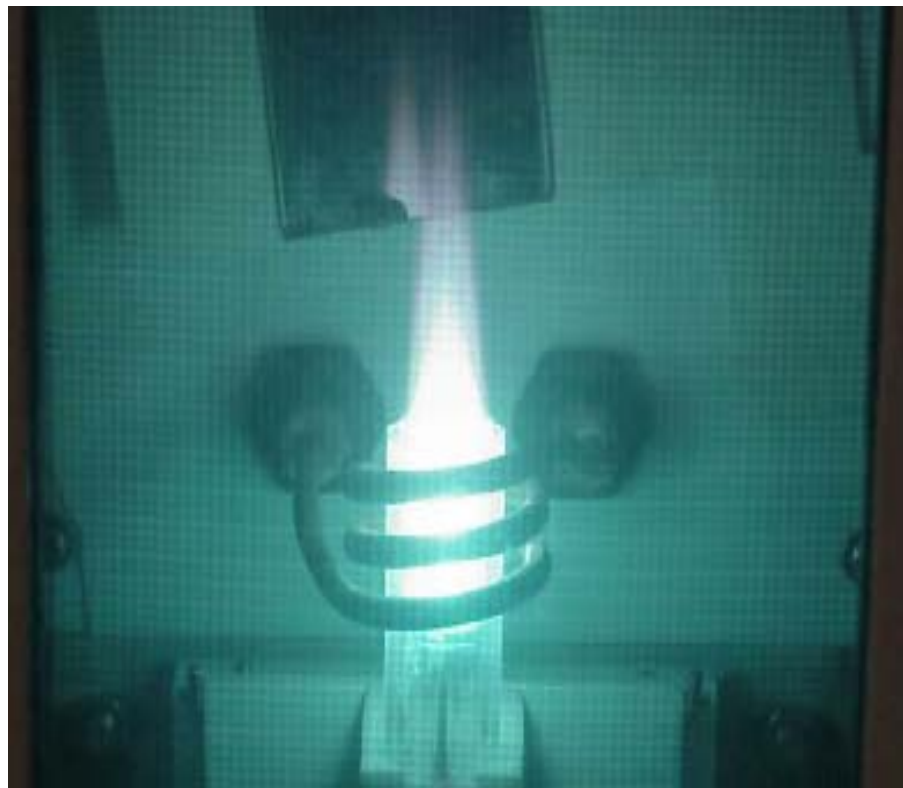


1959



2000

Atomic Emission Spectroscopy

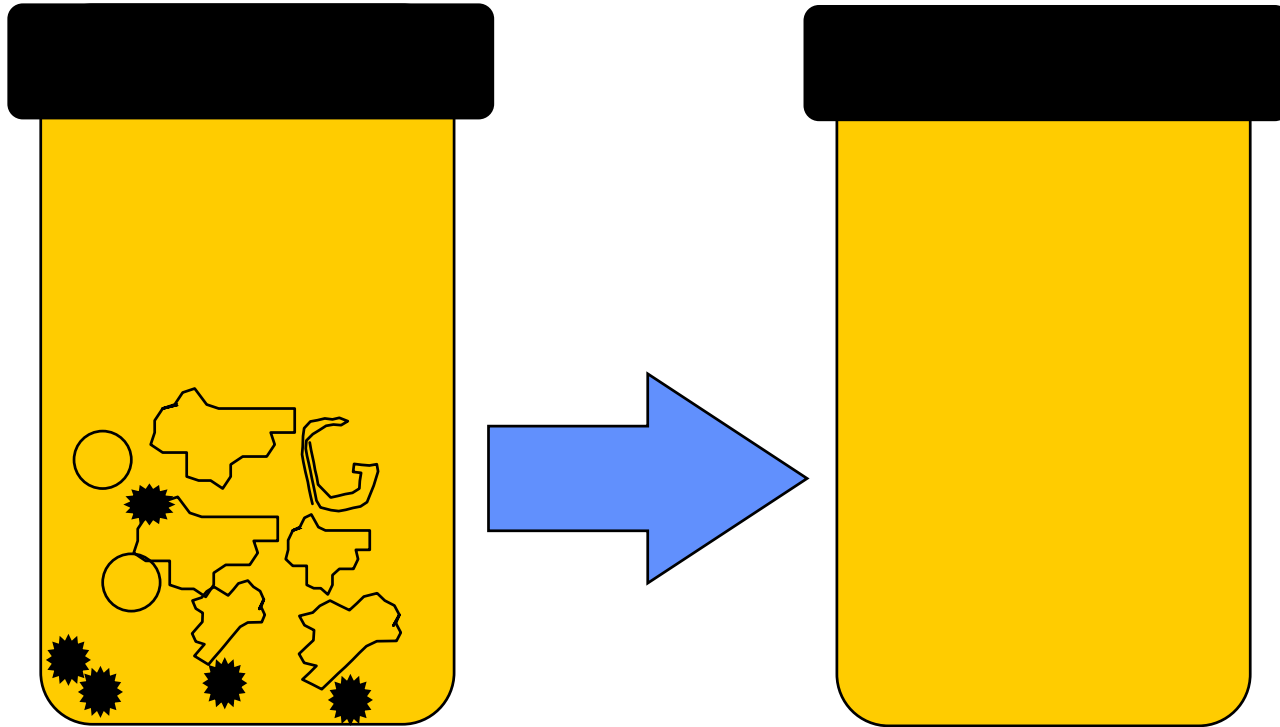


Atomic Emission Spectroscopy

Detecting large wear debris

Acid Digestion

Acid Digestion

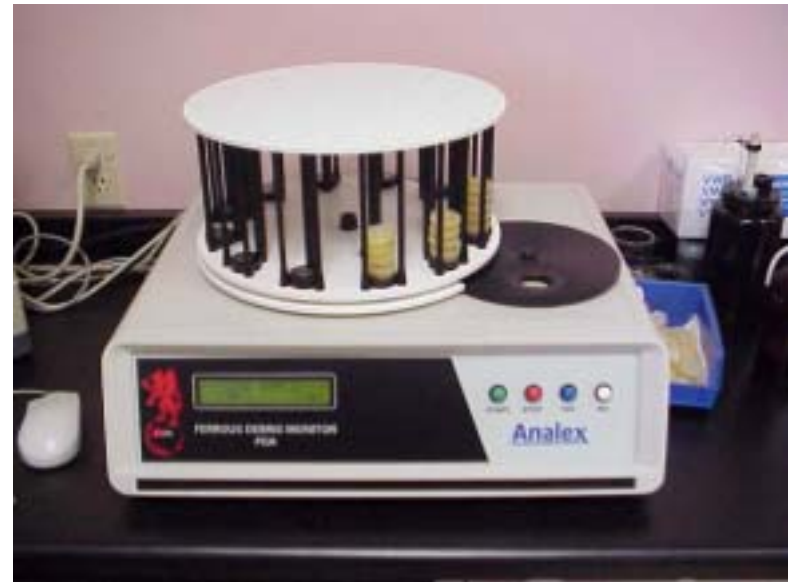


**Add Strong Acid to dissolve
(solubilize) wear debris**

Wear Particle Concentration Techniques



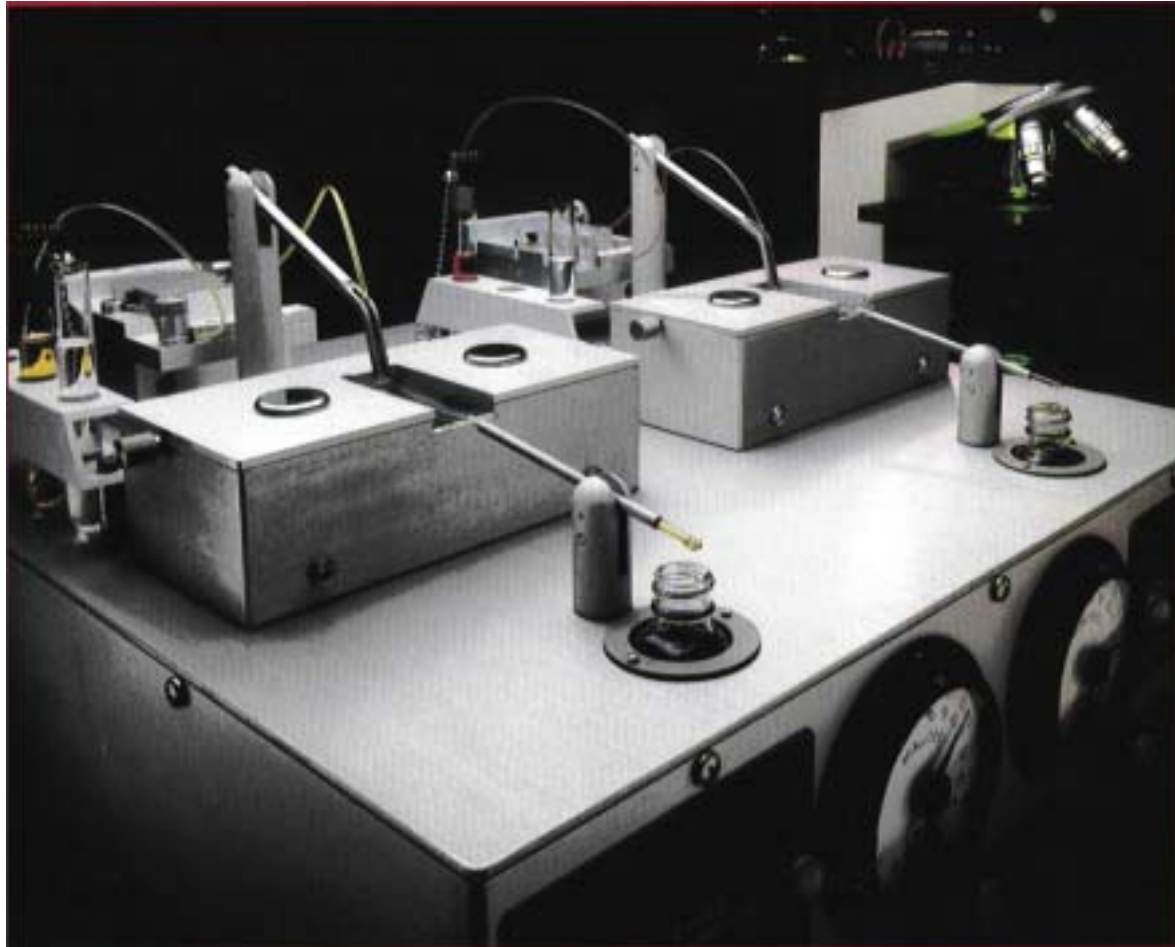
Direct Reading Ferrograph



Particle Quantifier

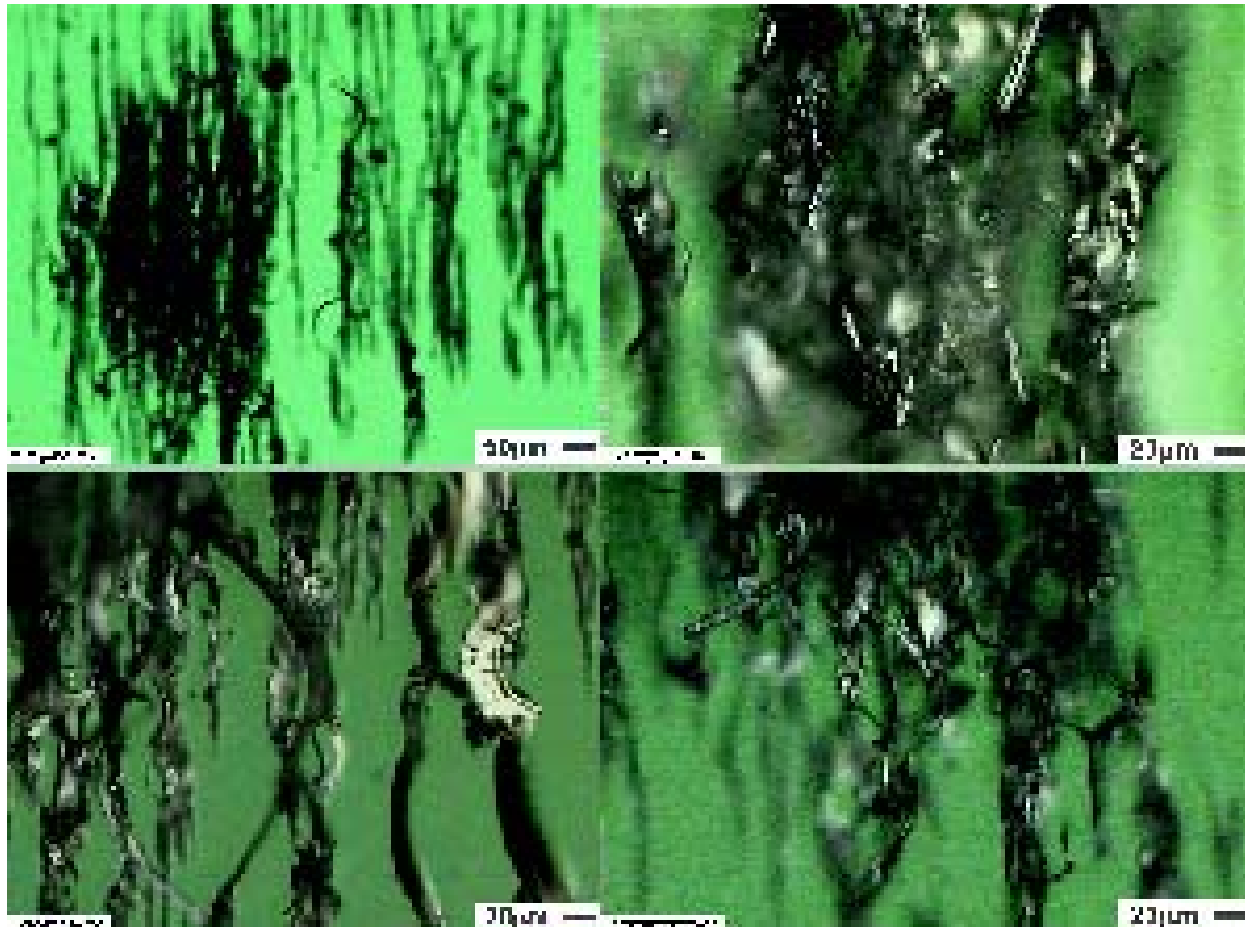
Wear Particle Analysis

WEAR RATES AND MECHANISMS



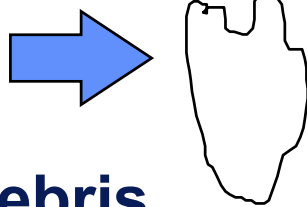
Wear Particle Analysis

WEAR RATES AND MECHANISMS

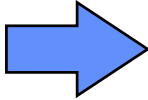


Heat Treating of Ferrous Debris

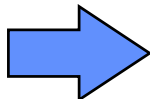
As
Received
Ferrous Debris



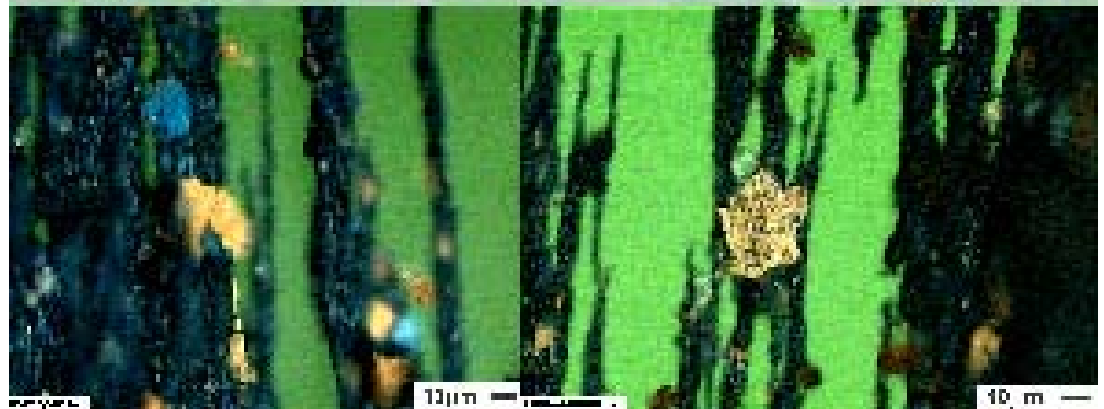
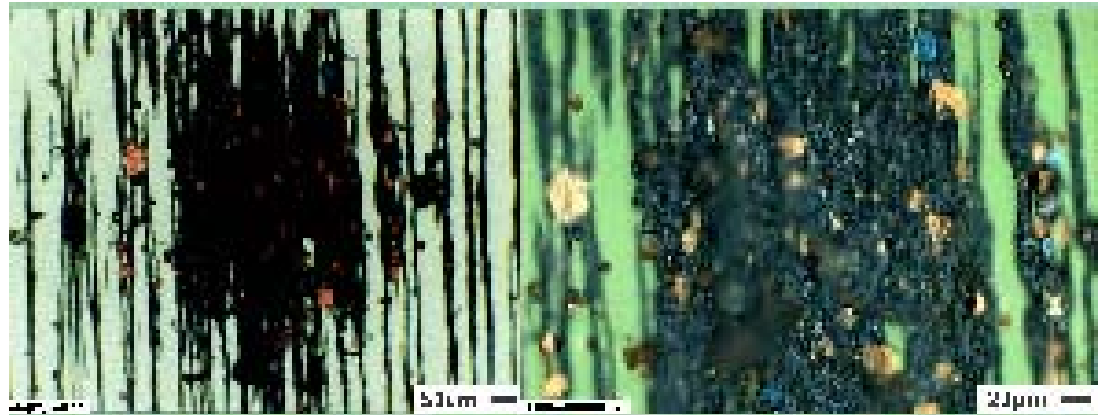
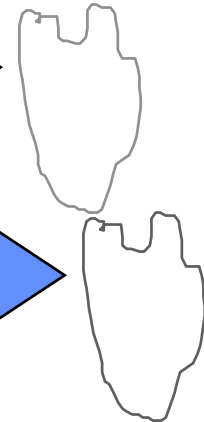
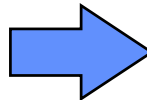
Heated
to 650F



Heated
to 850F

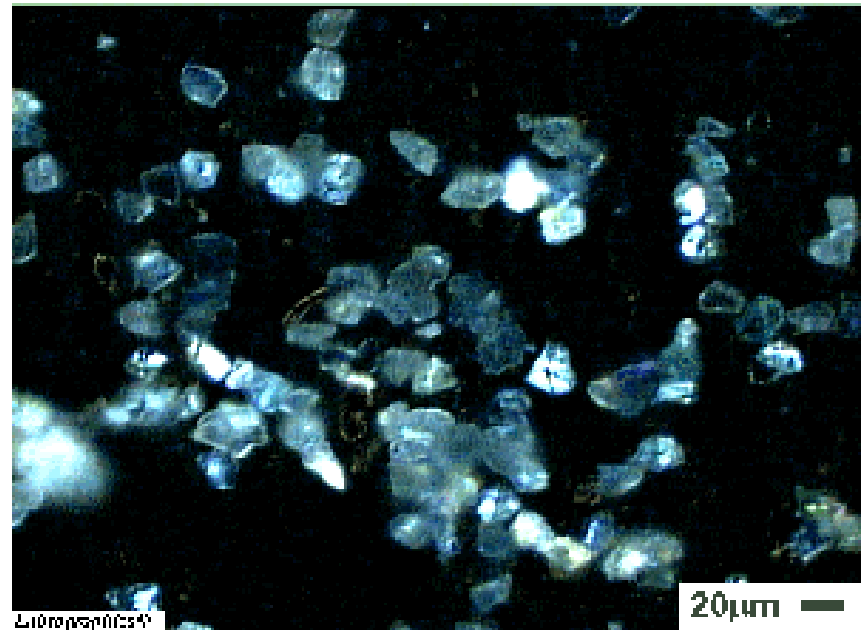
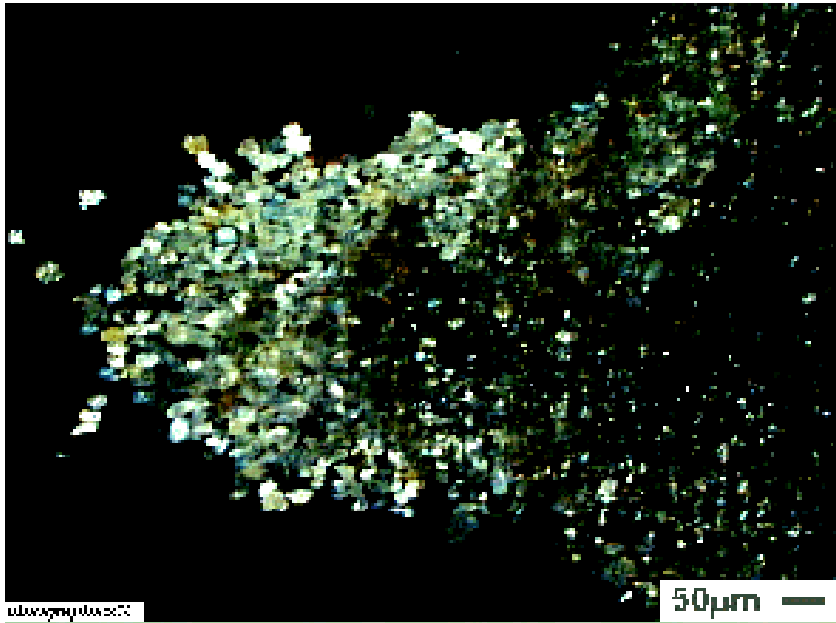


Heated
to 1000F



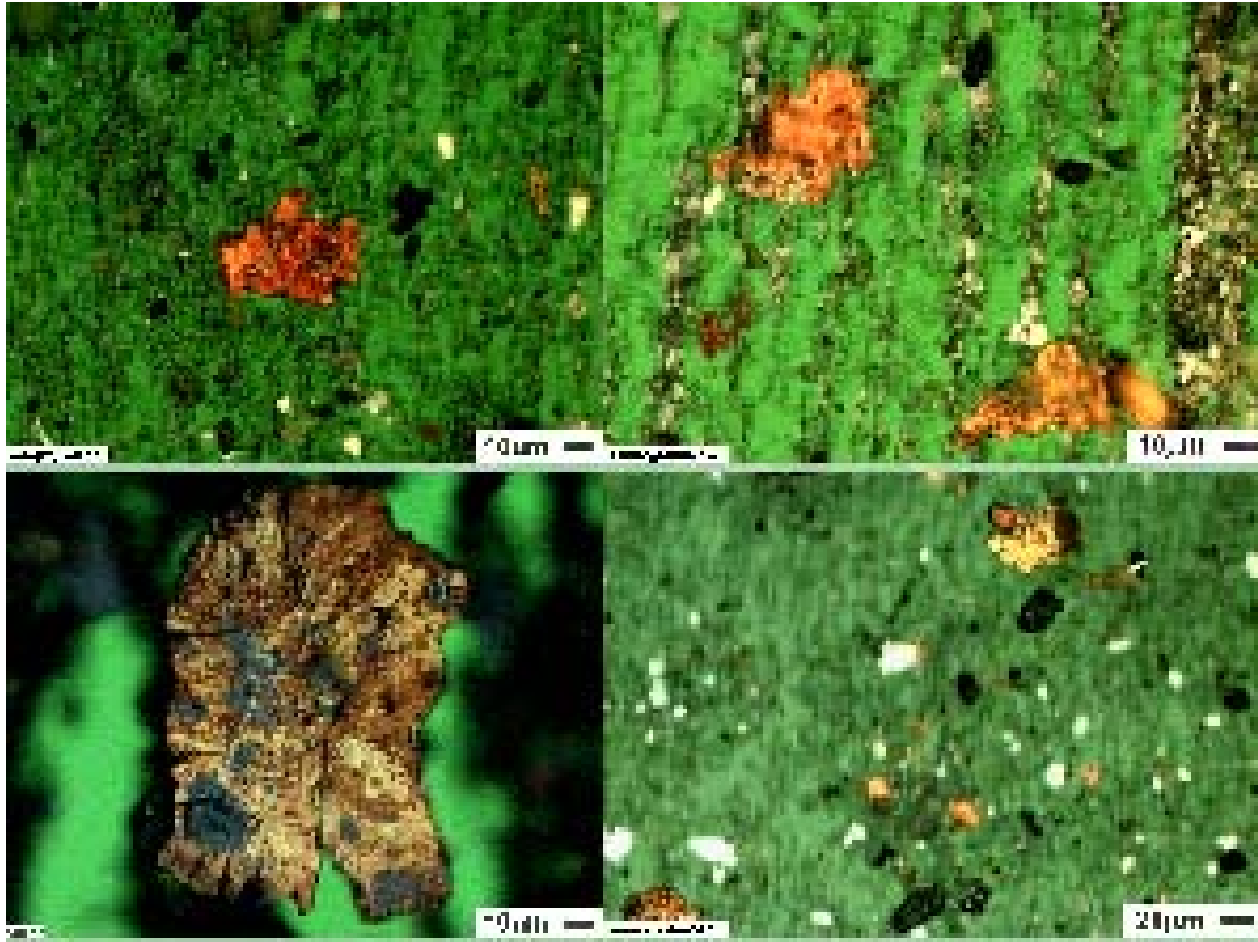
Wear Particle Analysis

Silica / Dirt



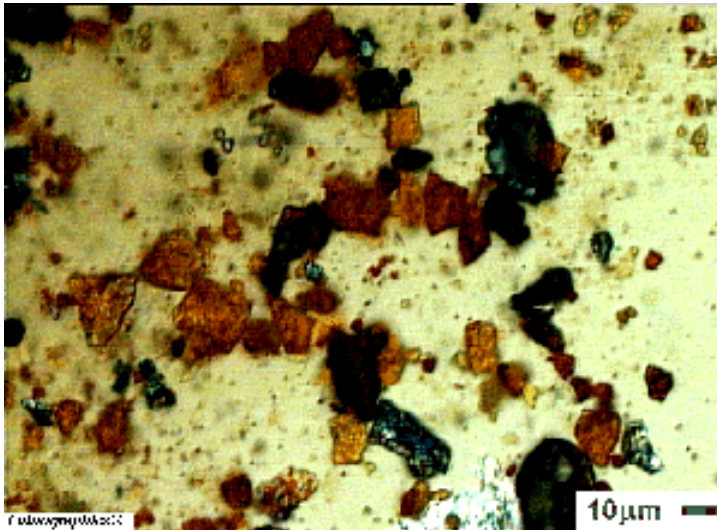
Wear Particle Analysis

Non-Ferrous Bronze / Aluminum

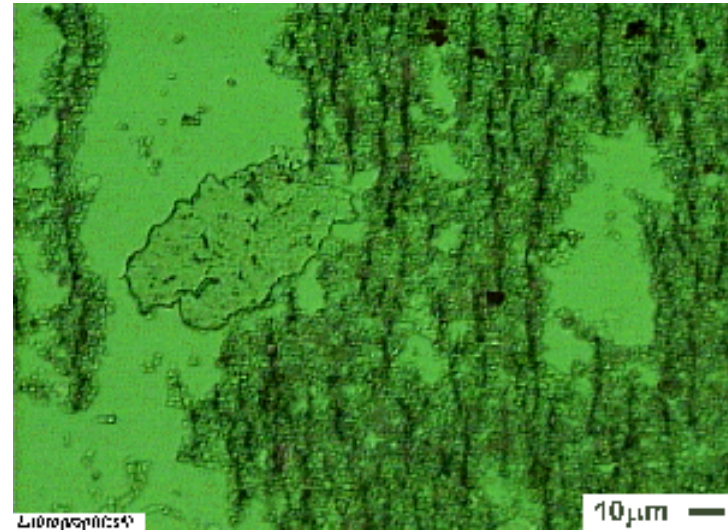


Wear Particle Analysis

Rust / Friction Polymers

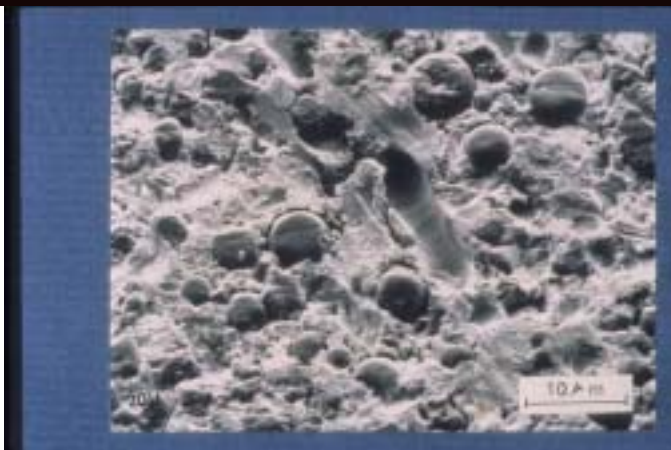
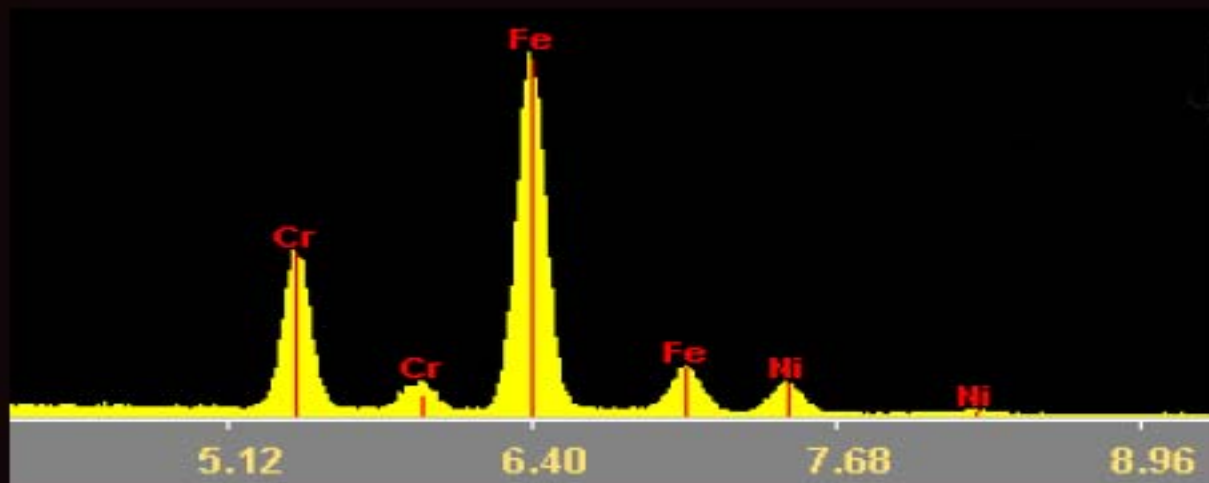


Rust

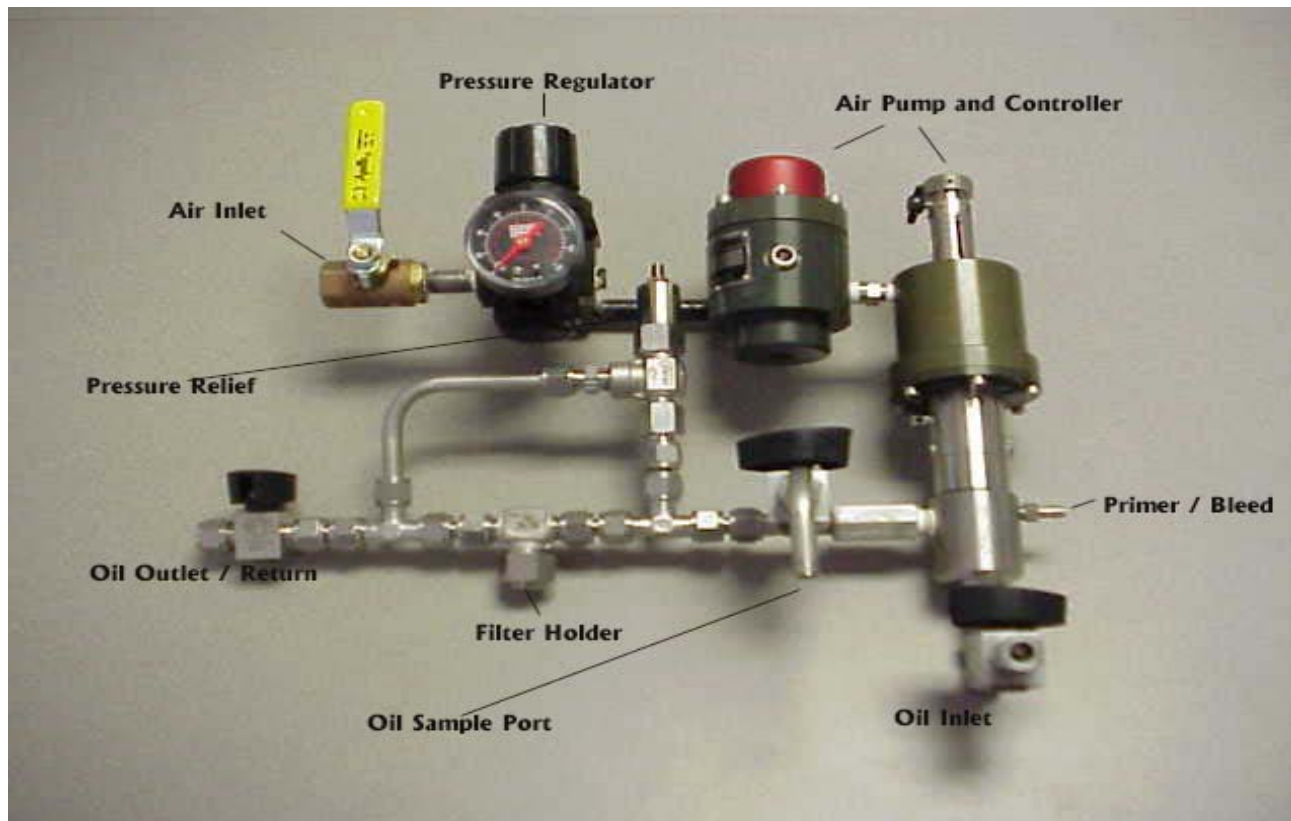


Friction Polymers

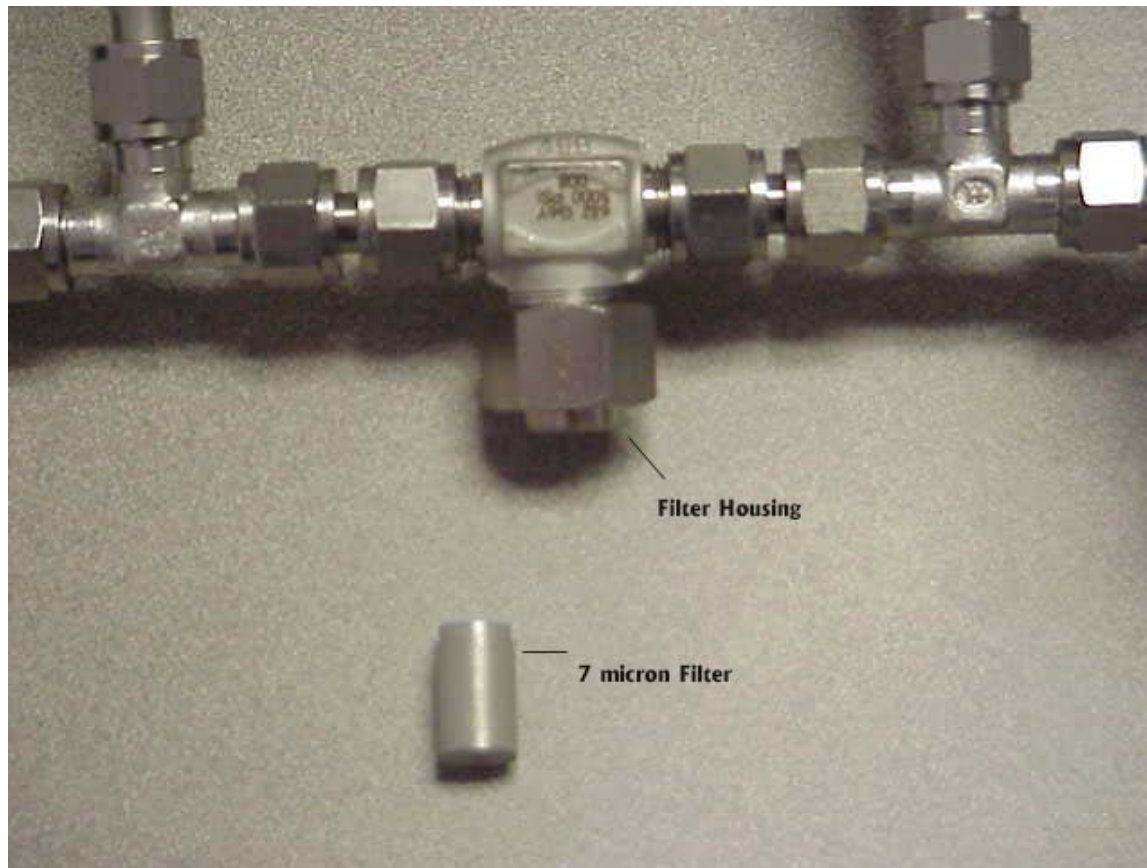
SCANNING ELECTRON MICROSCOPY / ENERGY DISPERSIVE SPECTROSCOPY



Possible Solution for Variations in Metals Analysis Assembly For Filter



Control Volume / Analyze Debris from Filter



METALS DOESN'T REVEAL

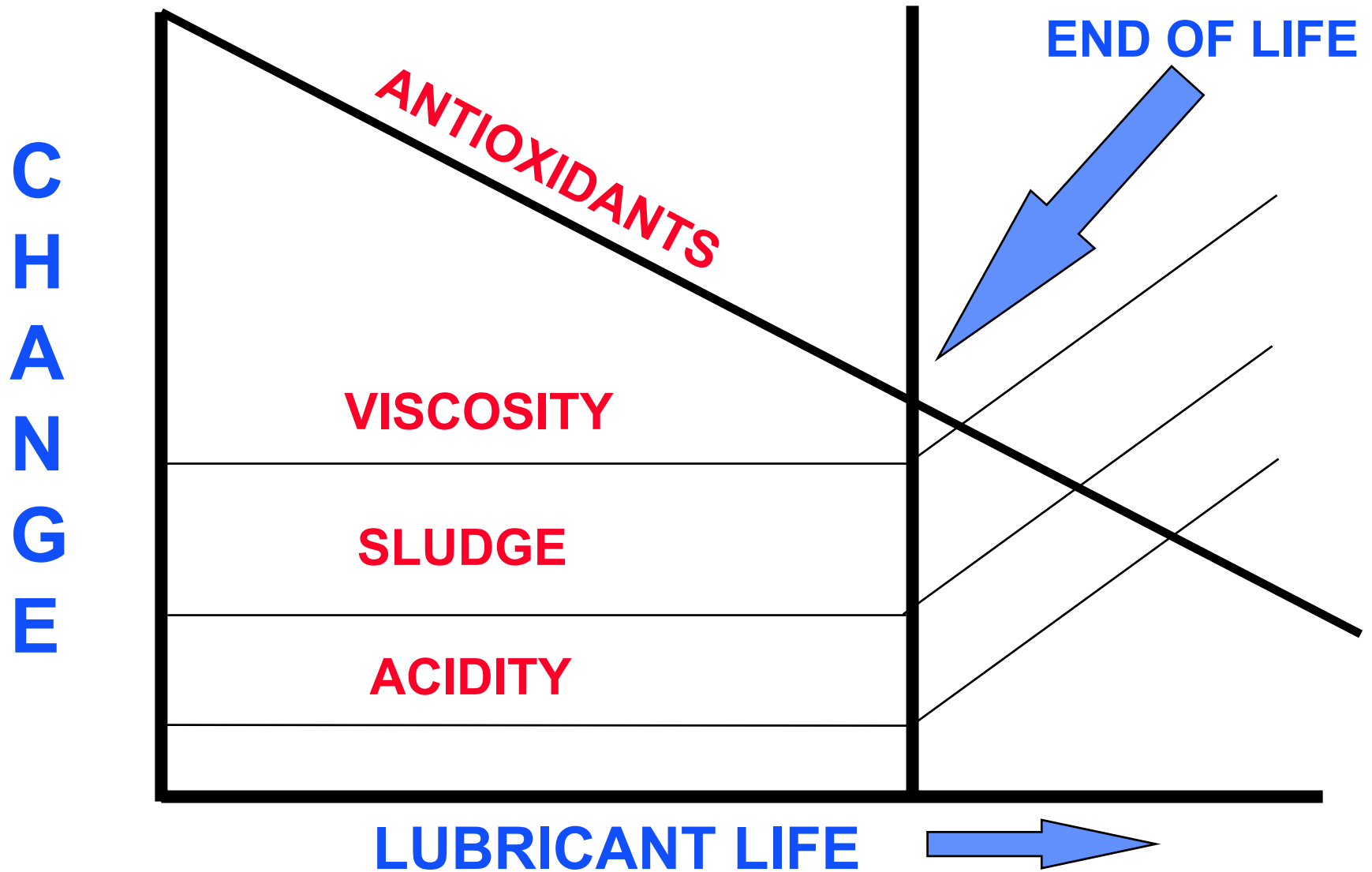




Herguth Laboratories, Inc.

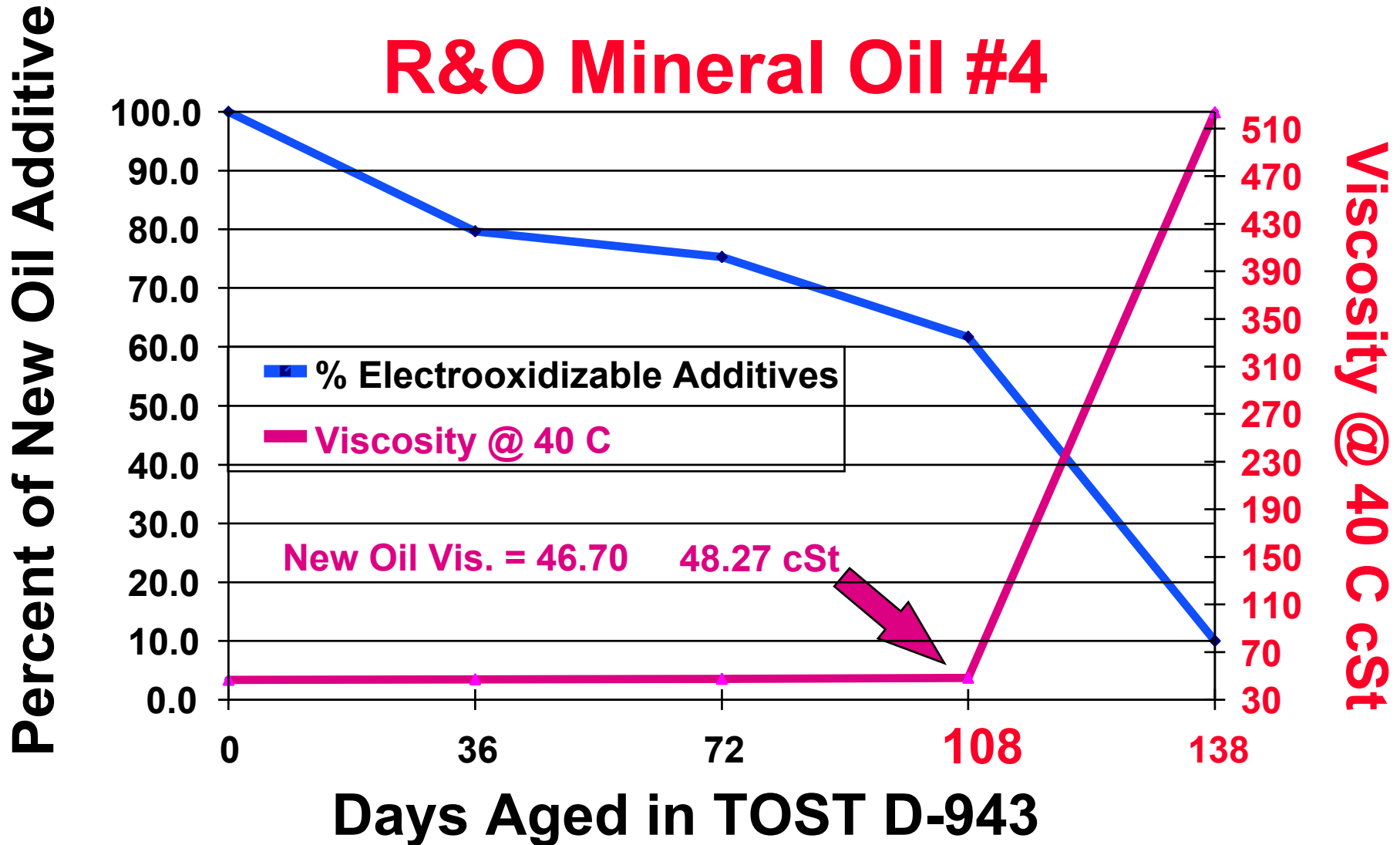
LUBRICANT HEALTH
Oil Degradation
And
Contamination

RELATIONSHIP OF PROPERTIES



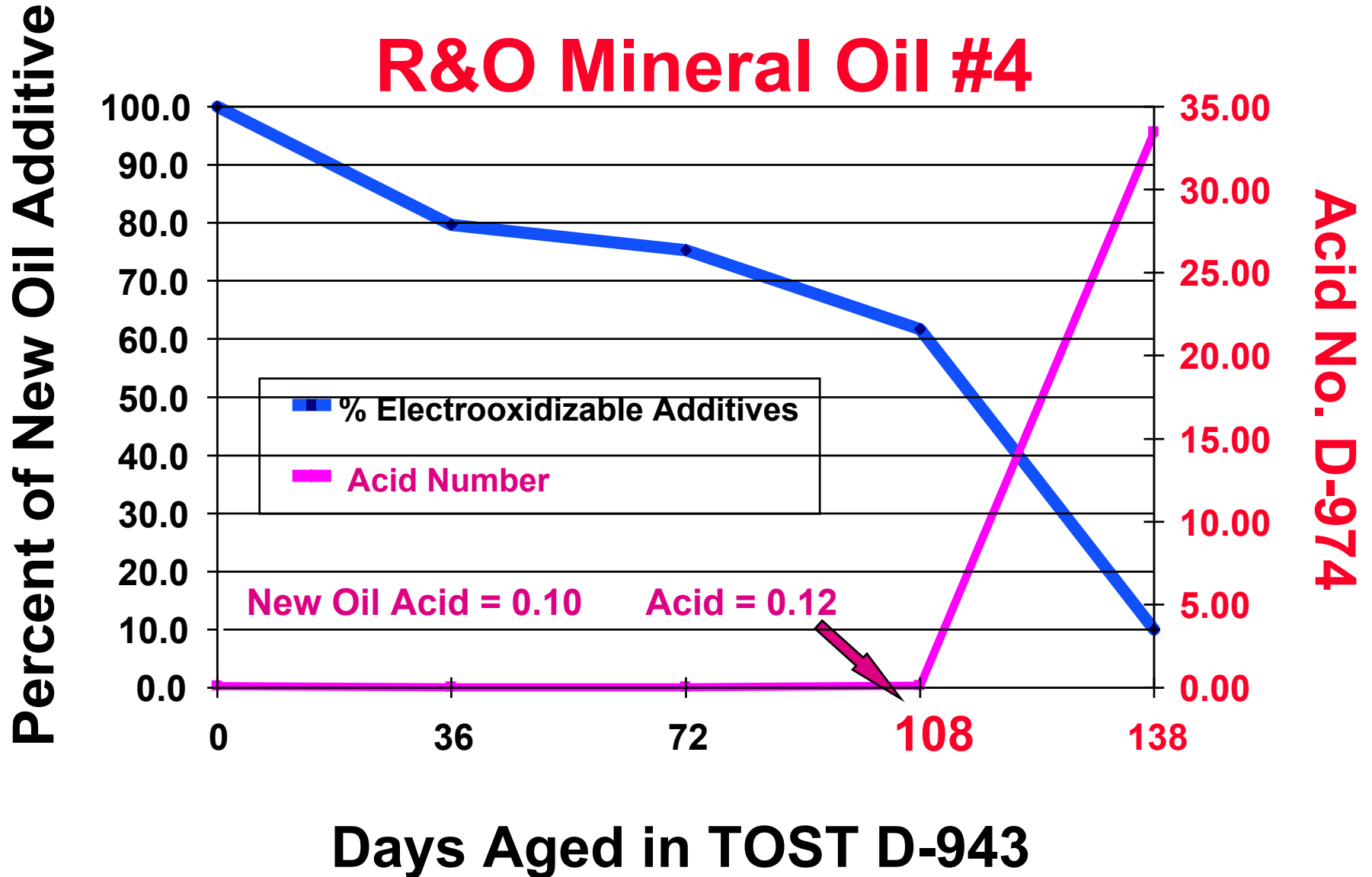
% Additives vs. Viscosity @ 40 C cSt D-445

R&O Mineral Oil #4

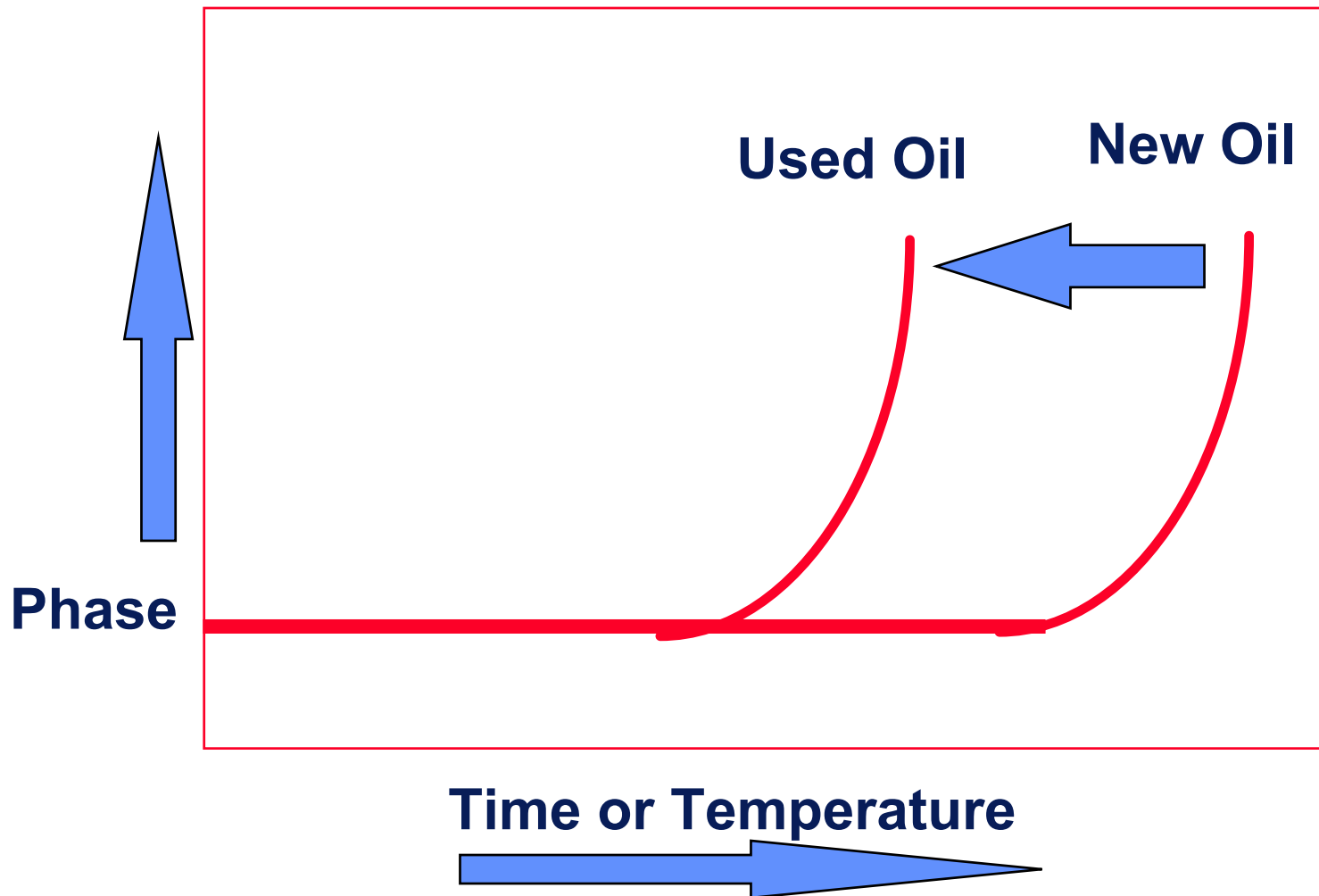


% Additives vs. Acid No. D-974

R&O Mineral Oil #4



DSC (Differential Scanning Calorimetry)



Viscosity Changes

Where To Look

Contaminant	Result
Different Lubricant	Change
Oil Shearing	Lower
Water	Change
Semi-Solids	Increase
Products of Oxidation	Increase
Test Results / Sample	Change

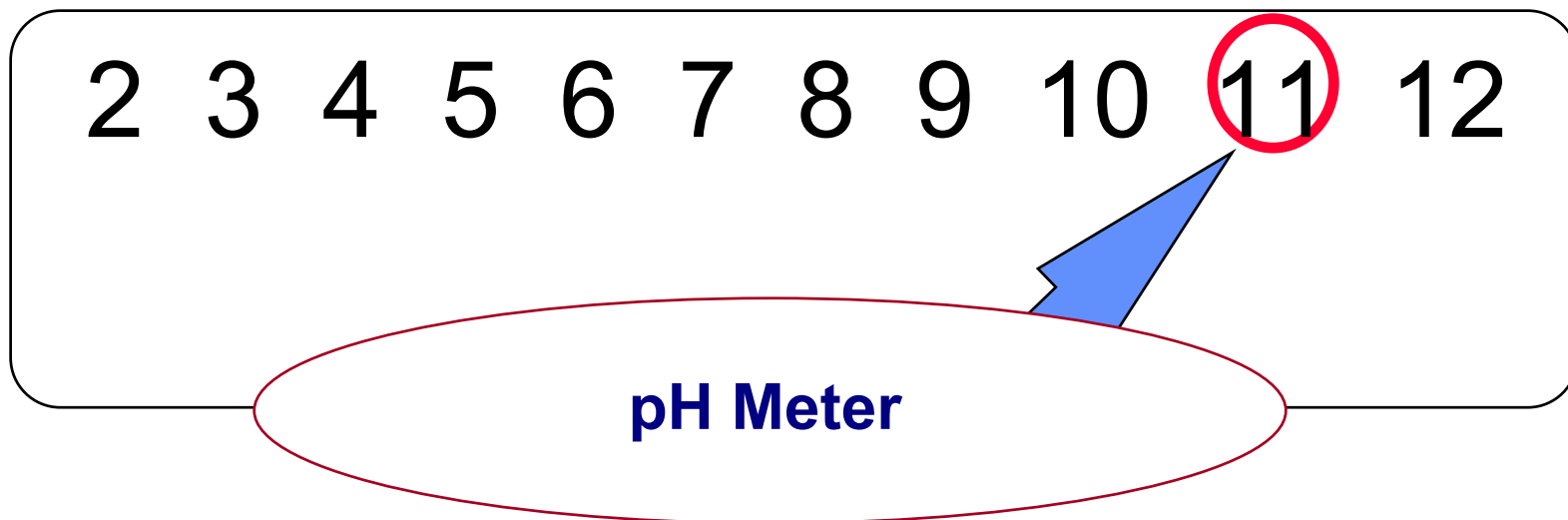
Acids

Oil forms acids when it oxidizes.
These acids accelerate the oil oxidation
The acids can also corrode equipment
as they circulate through the system.

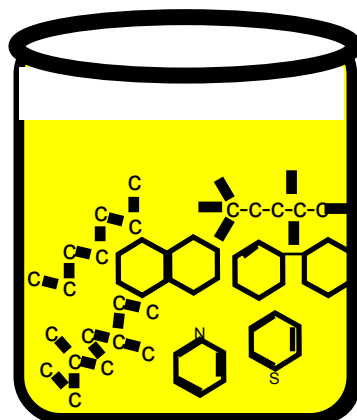


Acid Number

Neutralize Acids with Basic KOH (Potassium Hydroxide)



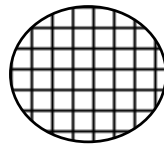
Most Industrial Oils



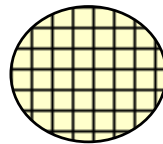
Solids and Semi-Solids

Filter Residue

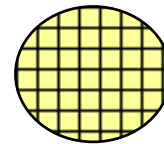
A clean dry filter is weighed The sample is drawn through the filter, and washed with solvent to remove residual oil
Report as mg/100 ml of residue



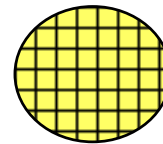
1, New Oil



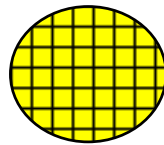
2, 500 H



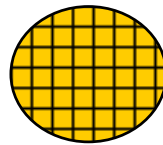
3, 750 H



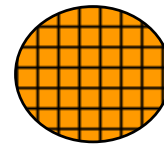
4, 1000 H



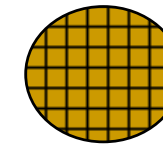
5, 1250 H



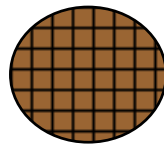
6, 1500 H



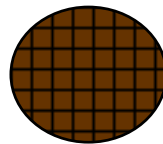
7, 1750 H



8, 2000 H



9, 2250 H



10, 2500 H

Contamination of Lubricants

Contaminates Have Three Forms:

Fluid (Water or Oil)

Semi-Solid (Oxidation Resins, Oil Additive Reactions, Polymer Separation)

Solid (Rust, Dirt, Wear Metals, Fibers, Slag, etc.)

- **Water by Karl Fischer**
Mix sample with a chemical reagent
Monitor reaction with digital probe & meter



FACTS About Lubricant Contamination

- **Contamination levels remain consistent under consistent operating conditions.**
- **Increased contamination is caused by the introduction of contaminants via maintenance, wear or faulty peripheral components (seals, filters, breathers)**

Particles Generated By Machine =	100,000 per unit of time
PLUS Seals, Breather Ingress =	50,000 per unit of time
MINUS Filter Removal =	75,000 per unit of time
Particle Accumulation =	75,000 per unit of time

ISO Solid Contaminant Code

MORE THAN	UP TO	CODE
40,000	80,000	23
20,000	40,000	22
10,000	20,000	21
5,000	10,000	20
2,500	5,000	19
1,300	2,500	18
640	1,300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5	9
1.3	2.5	8
0.64	1.3	7

Bottle Cleanliness Levels Target = 18/16/13

- **Standard Bottle = 13/11/7**
SN = 31/32/61 Very Good SN Ratio
- **Ultra Cleaned = 10/7/5**
SN = 250/640/250 Excellent SN Ratio
- **Ribbed Cleaned = 9/8/7**
SN = 500/256/61 Excellent SN Ratio

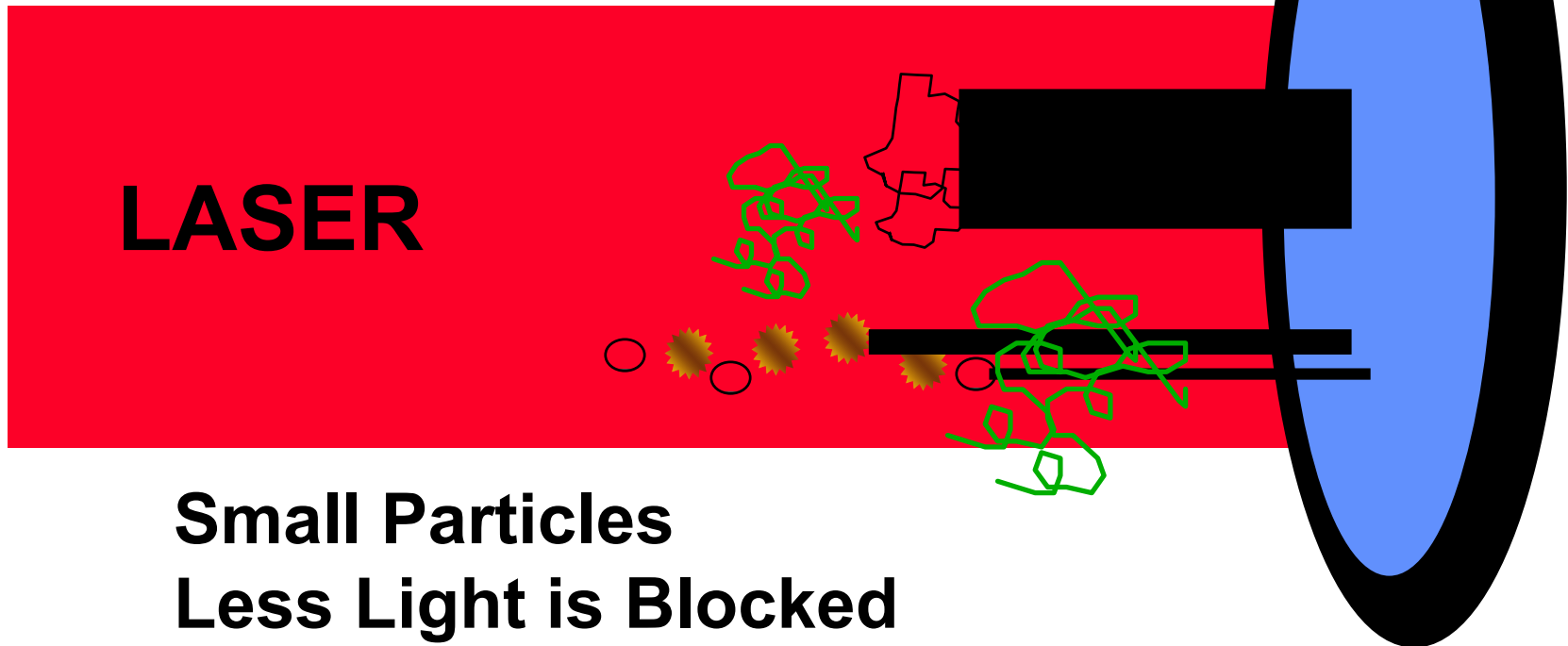
Once Again ... SN = Target / Bottle

Contamination of Lubricants

Light Blockage Solids

Large Particles
More Light is Blocked

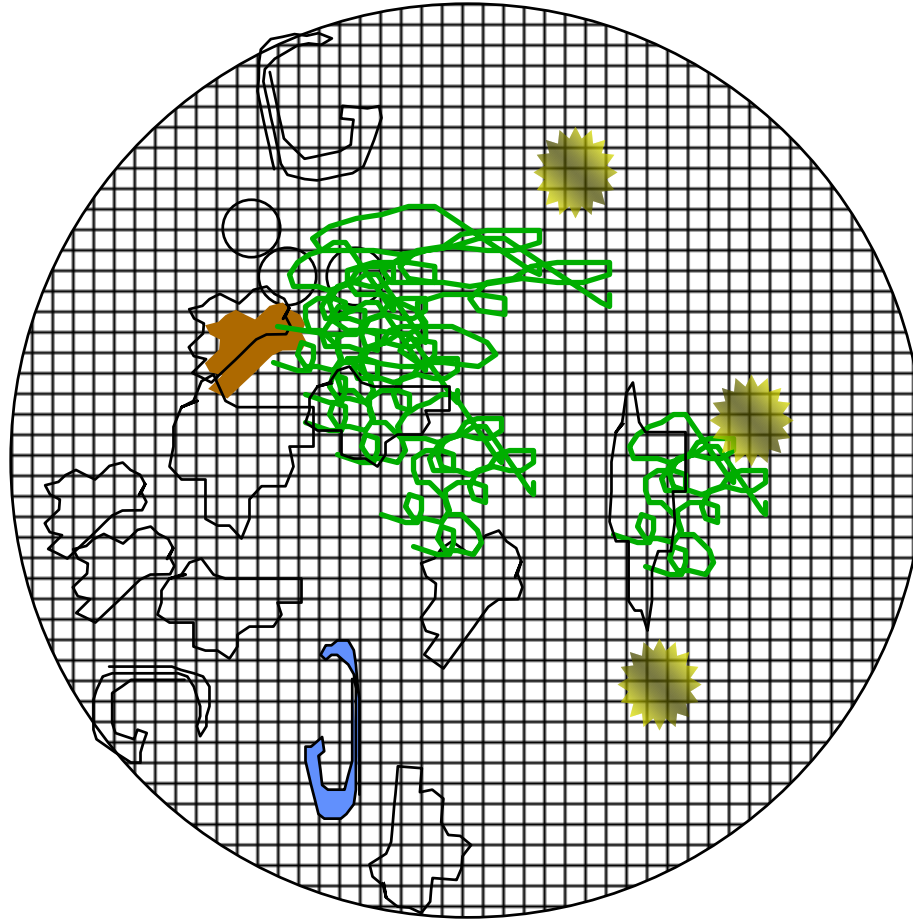
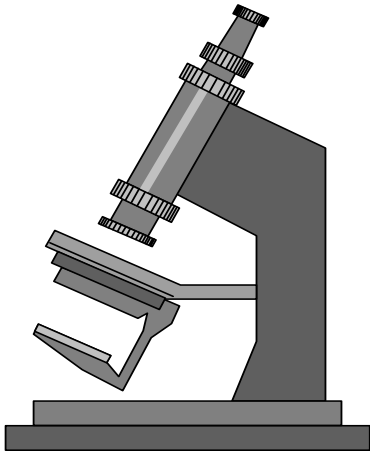
Collector



Contamination of Lubricants

Solids

Microscopic Particle Counters





Herguth Laboratories, Inc.

Thank you!

Questions?